LOW BIT RATE SPACECRAFT G&C - MISSION OPERATION CHALLENGES*

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ABSTRACT

Future spacecrafts are destined to be more autonomous, cheaper to develop and to operate. As part of the spacecraft program end-to-end budget, mission operations have traditionally been a noticeable line item, particularly for long-duration planetary missions.

This paper addresses mission operation challenges and solutions in the area of Attitude and Articulation Control Subsystem (AACS), which could lead to a more cost-effective spacecraft system as a whole. in particular, a subclass of autonomous spacecrafts is addressed here - those spacecrafts that have low bit rates. Low bit rate can refer to continual bit rates that are as low as 10 bits per second (bps); and it can also refer to periodic coverage/blackout, leading to low averages in bps for large data packets.

Challenges in low bps AACS mission operations include:

- Real-time monitoring, when on-board actions and reactions occur at faster rates than the sampling of observable states, which come in the form of downlinked telemetry;
- Reconstruction of spacecraft states from limited telemetry:
  (a) Reconstruction in terms of interpolating time. gaps in observable states, where the gaps result from low bit rates;
  (b) Reconstruction in term of exptrapolating from known observable states to derive unobservable states, which are not downlinked, or rarely downlinked;
- Matching predictions from ground simulation to actual spacecraft performance, under different degrees of visibility; and
- Decision making and commanding under limited visibility.

Solutions to meet these challenges include:

- Man-machine interface techniques to real-lime monitoring, as designed into information restructuring, reproduction, and displays in the ground systems;
- Analysis tools and software scripts calling a host of tools/utilities/program]s, which are easily adaptable to cater to a variety of real-time and off-real-time analysis situations;
- Models and analytical solutions to reconstruct space.craft states, by forward and backward (time) projections, interpolations and extrapolations;
- Information filtering, models to compare spacecraft information presented at different sampling rates and time spans;
- Effective man-machine interface. tools for iteration and interaction, where metrics are computed on-line for performance evaluation;
- Radical changes in the end-to-end information collection and dissemination system, aka telemetry system on board the spacecraft, and likewise in ground systems.

Examples are drawn from design and flight experience of Mars Observer, Galileo and Cassini.

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